New Radiation Safety Interlock System for the SPring-8 Accelerator Complex

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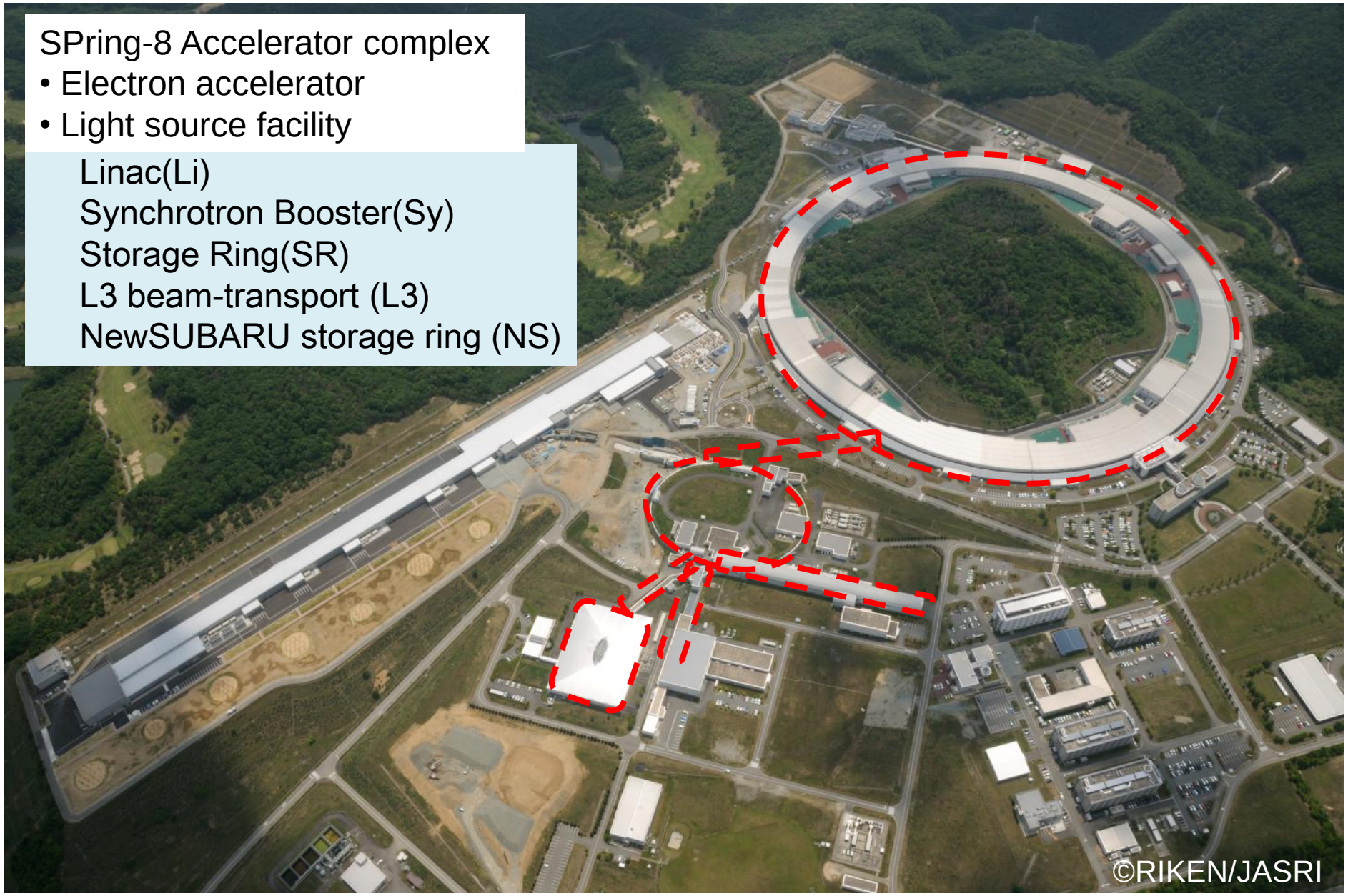
Outline

- Introduction
- Motivation
- New radiation safety interlock system
- Summary & Future

Introduction



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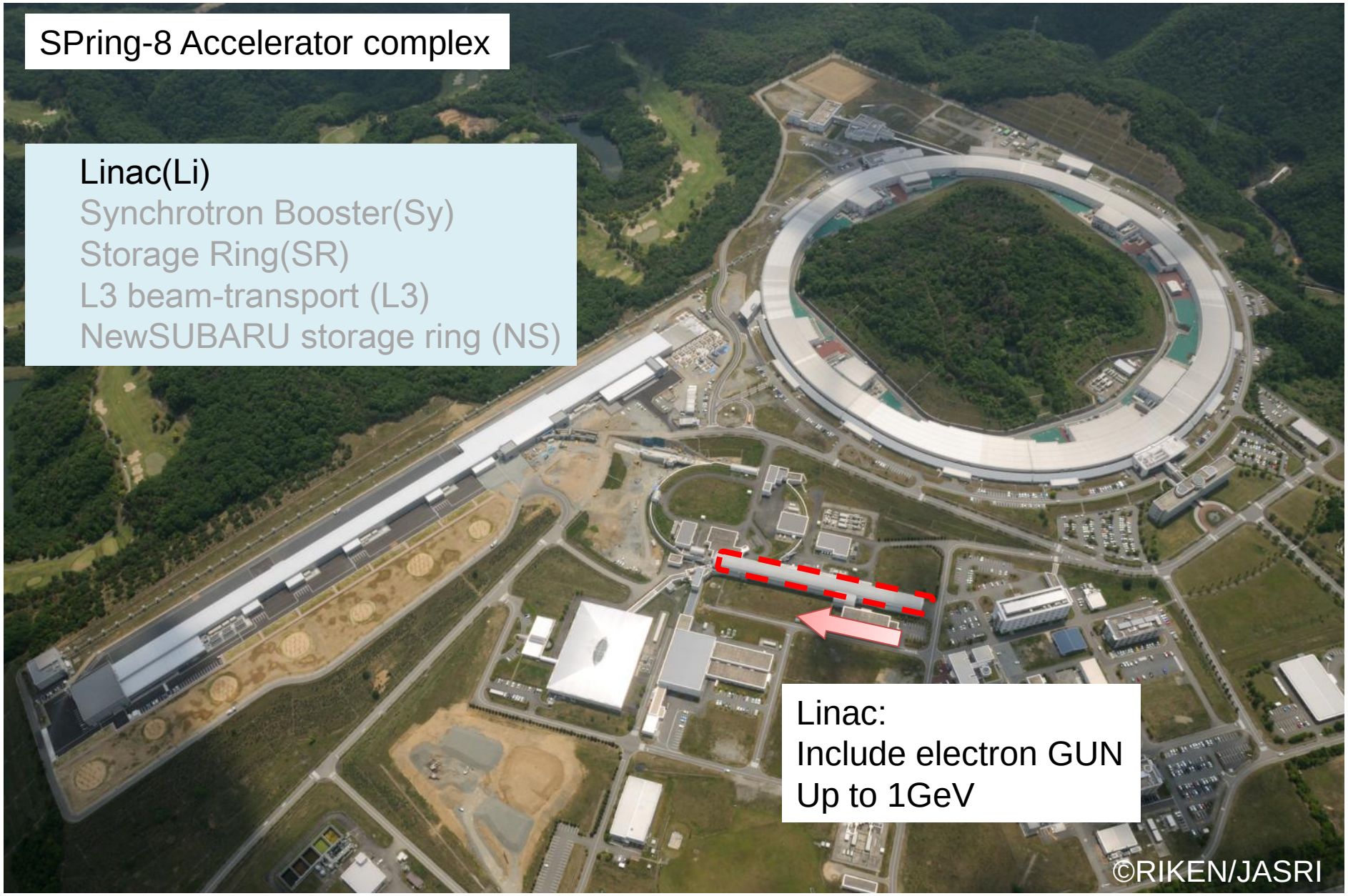

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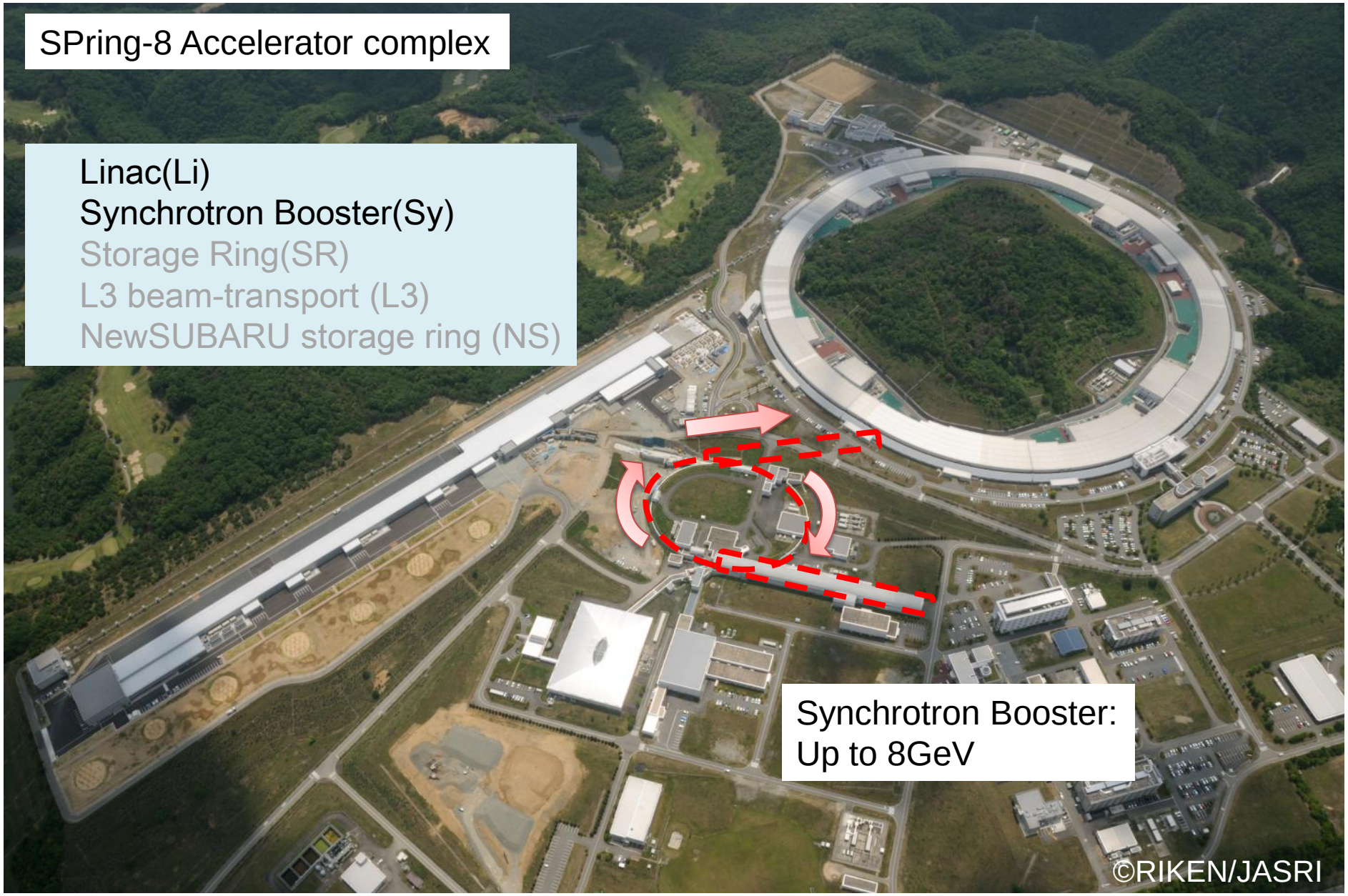

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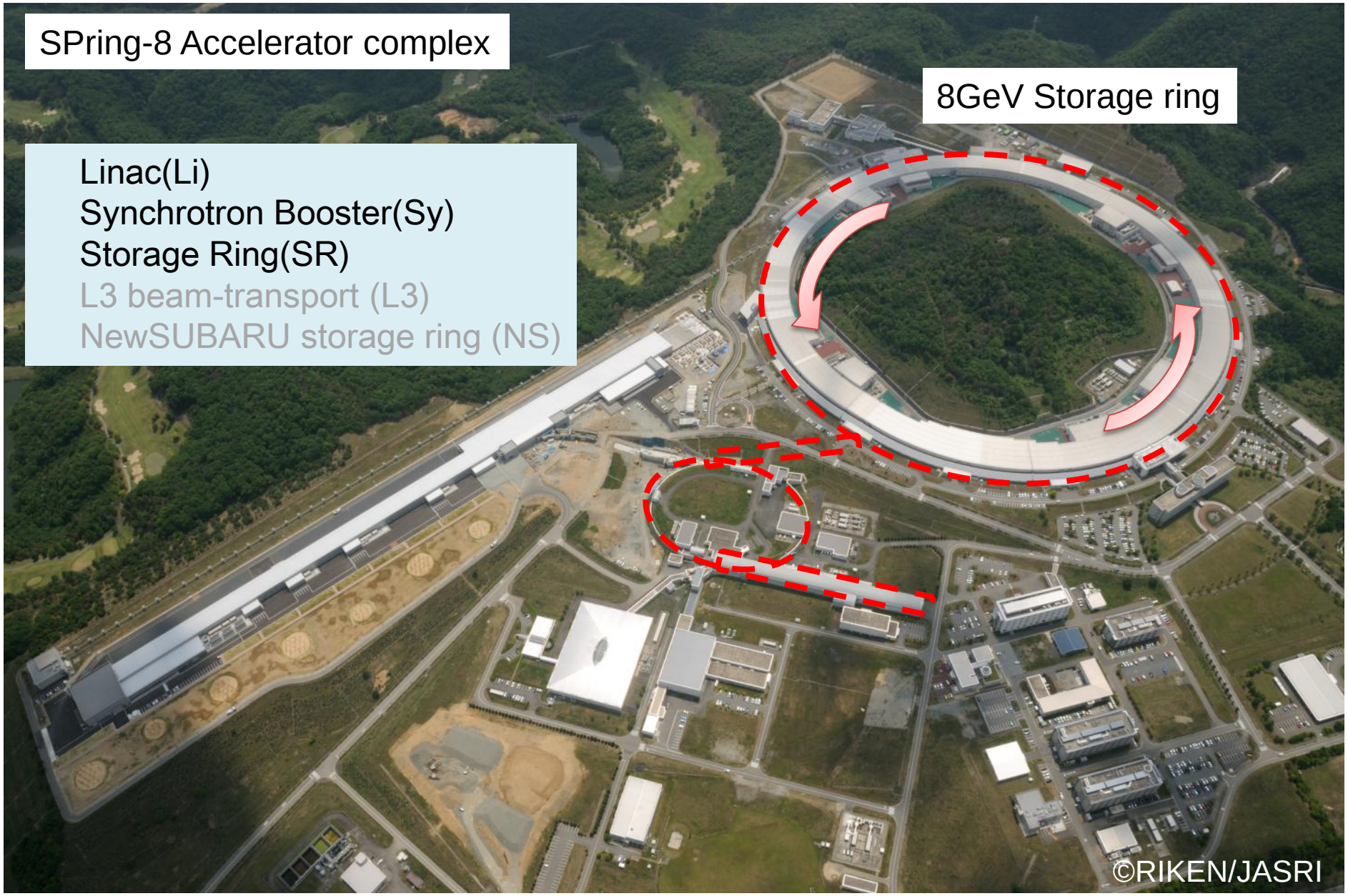

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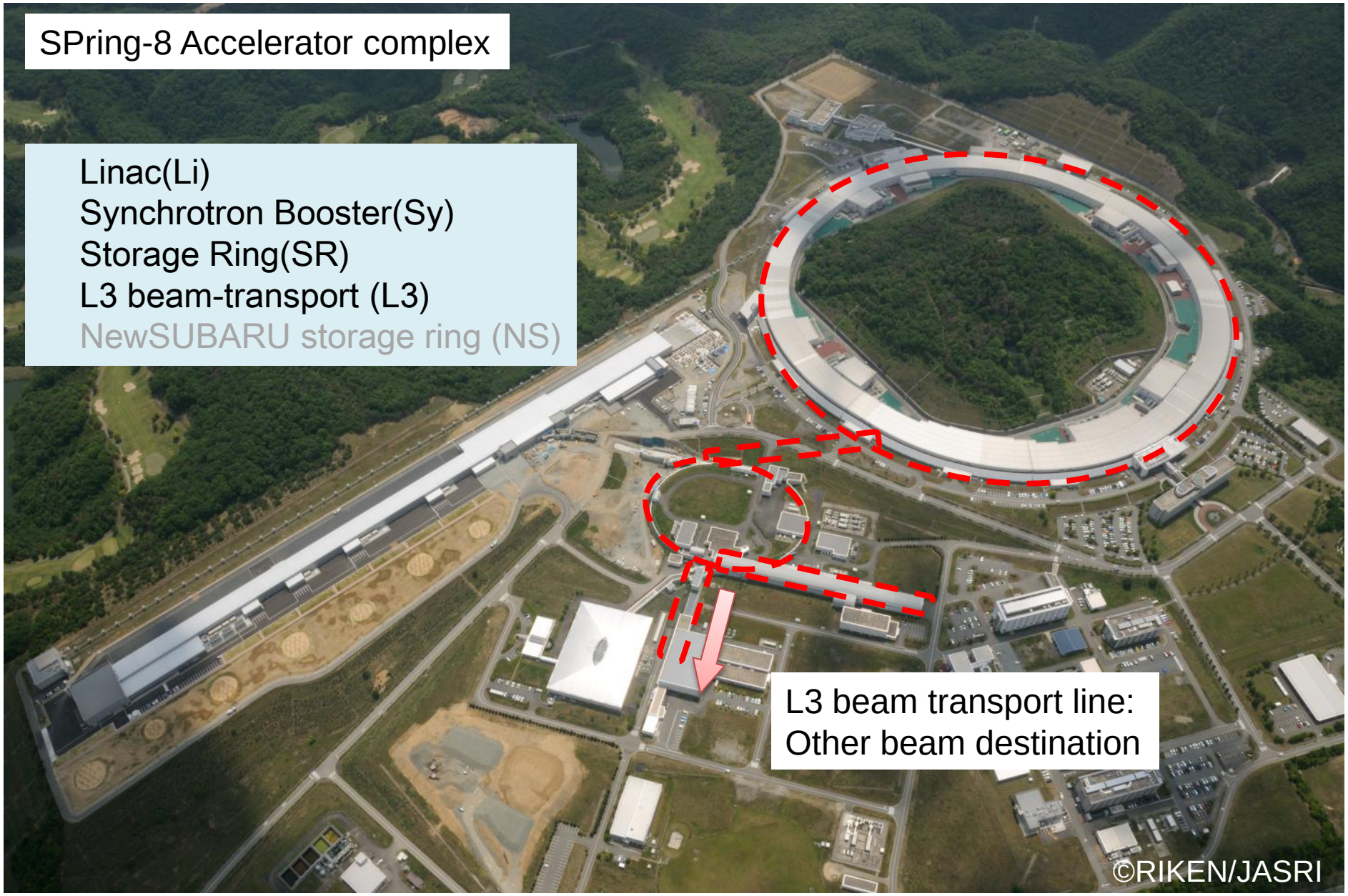

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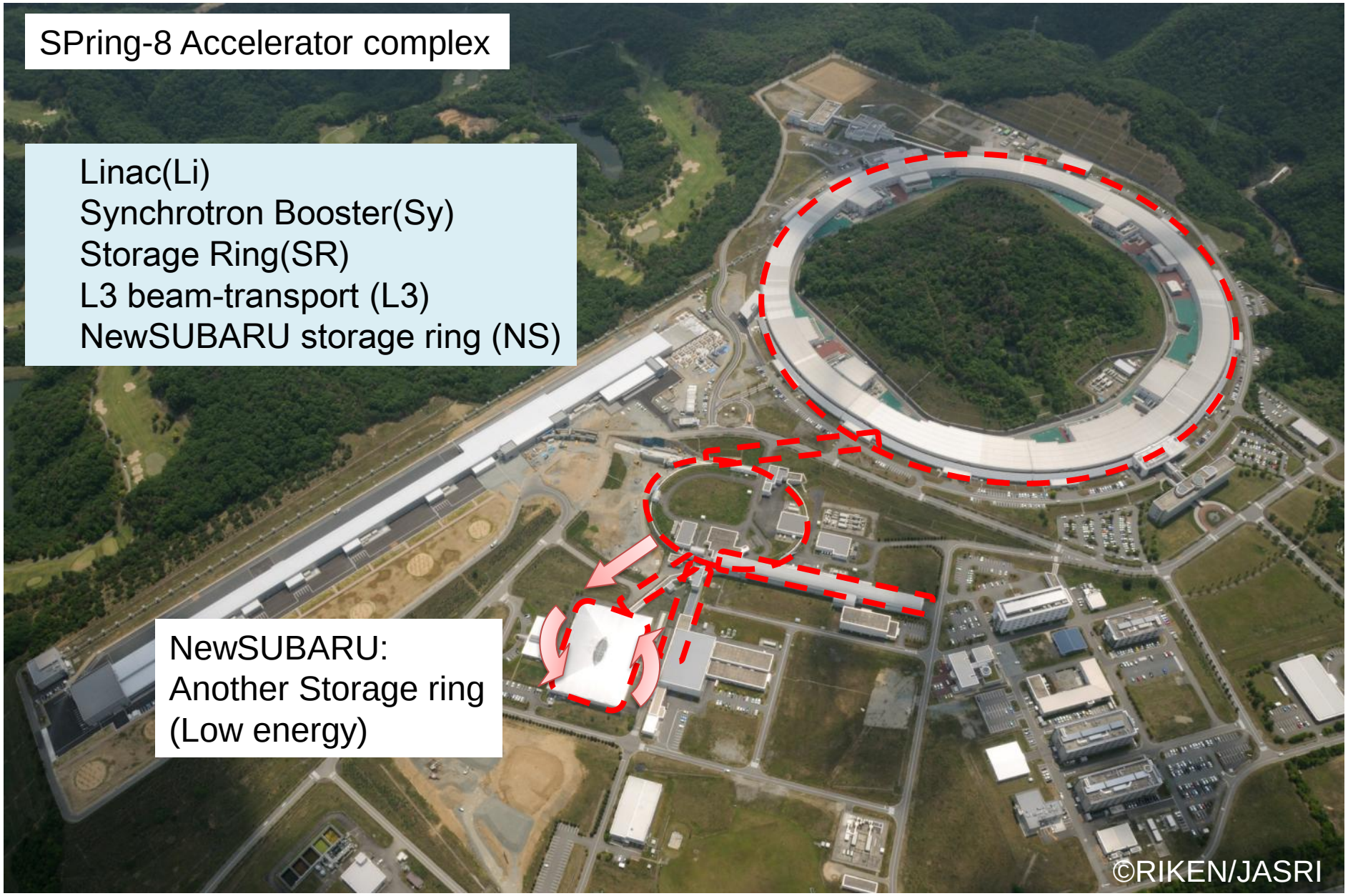


Accelerator Radiation Safety Interlock System

Purpose:

Protect persons from radiation hazard induced by electron beams and synchrotron radiation

Basic Function:

- Access control:
  Manage permission for entering radiation-controlled areas

- Monitoring safety equipment:
  Radiation monitor etc..

- Manage permission for GUN and RF

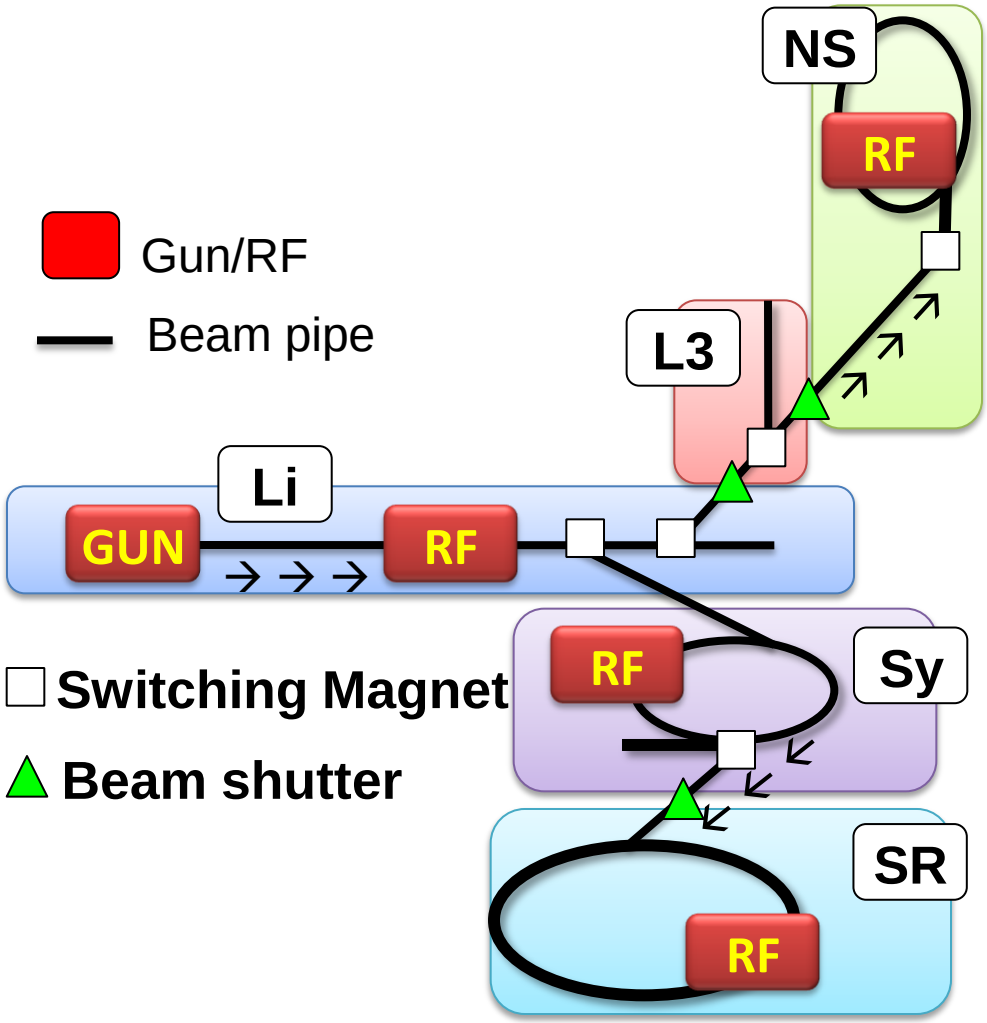
⇨ Strongly depend on the SPring-8 operation

Accelerator operation

- **Five access controlled areas:**
  Linac (Li)
  Synchrotron Booster (Sy)
  Storage Ring (SR)
  L3 beam-transport (L3)
  NewSUBARU storage ring (NS)

- **Beam generation/acceleration:**
  - One electron gun generates electron beam(GUN)
  - Electron beam is accelerated by RF cavity (RF).
  - Four RFs

- One electron GUN supplies electron beam to all area

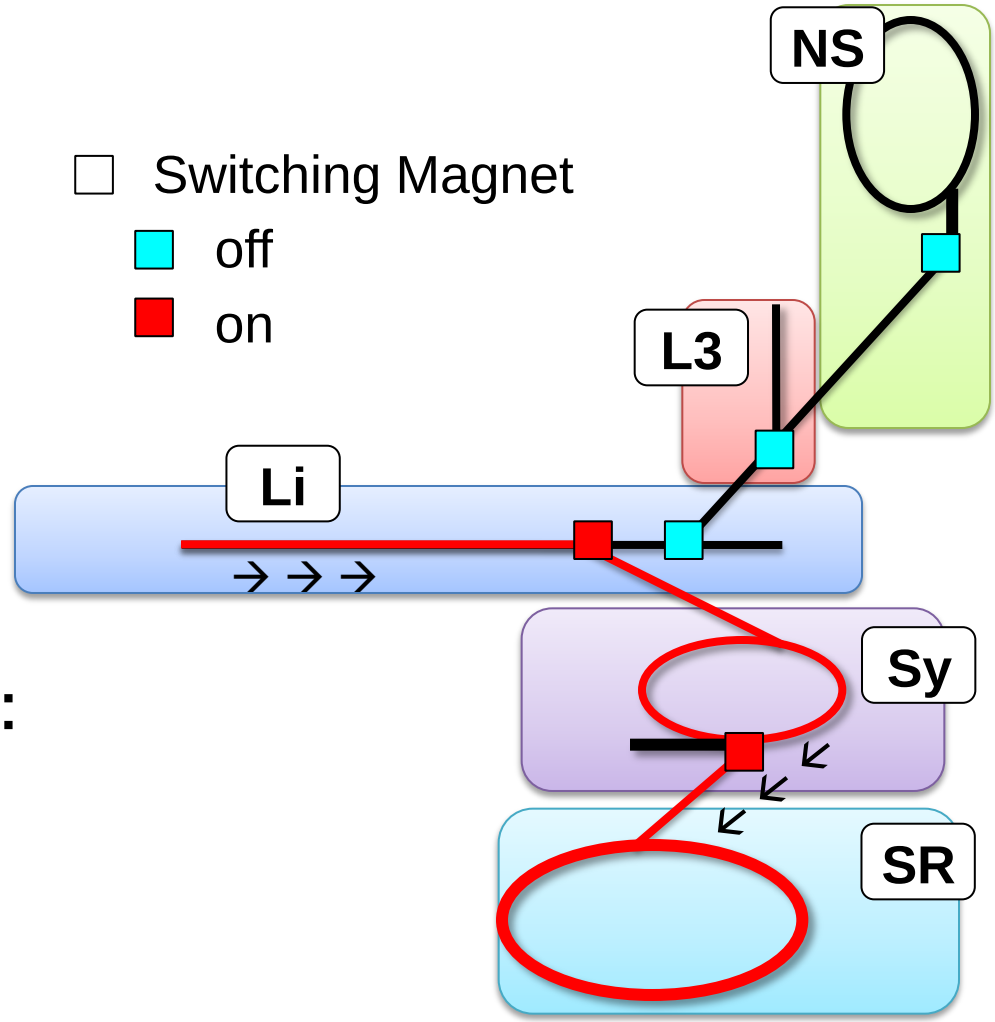


SPring-8 Accelerator complex

Combination of areas → Many kinds of operations

Various Accelerator Operations

SR injection operation mode



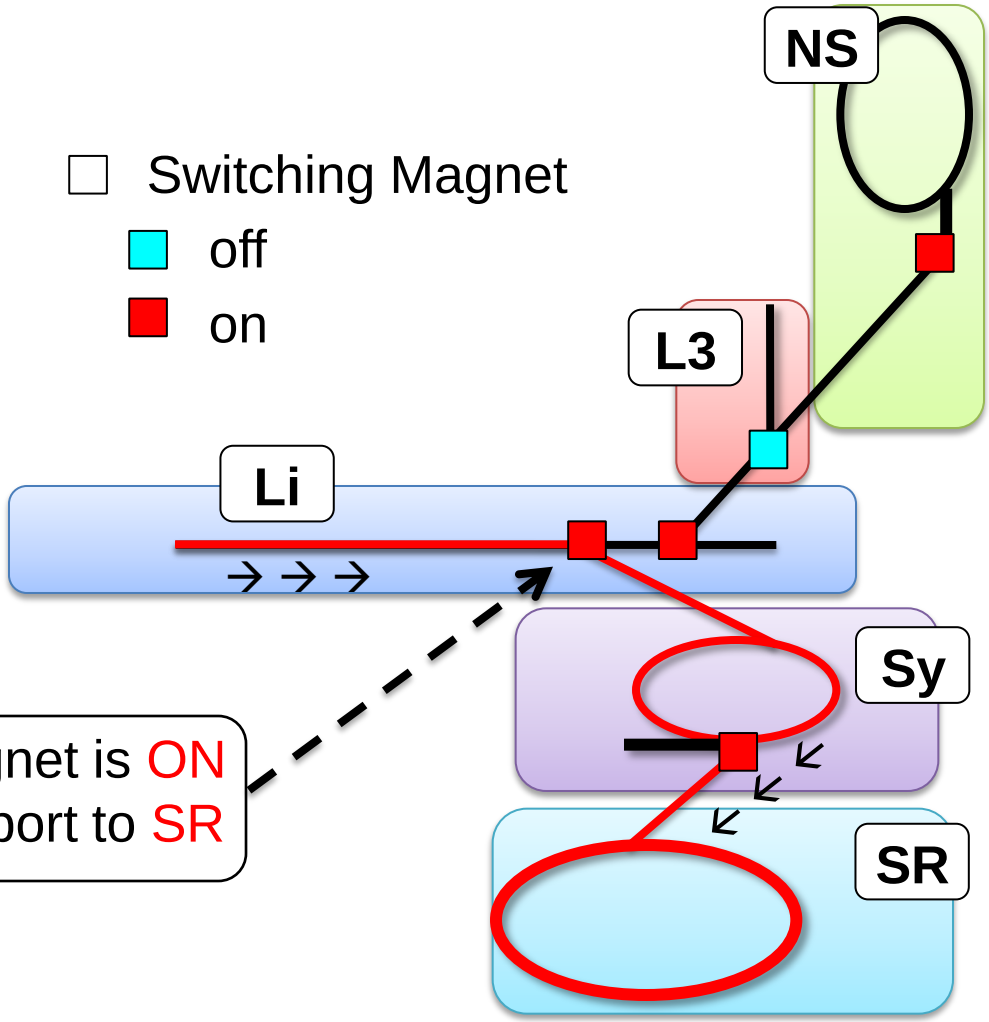
SPring-8 Accelerator Complex

- **Beam transportation route:**
  → Switching Magnets

Various Accelerator Operations

SR/NS injection
switching
operation mode

Beam destination is switched
by changing
one Switching Magnet status



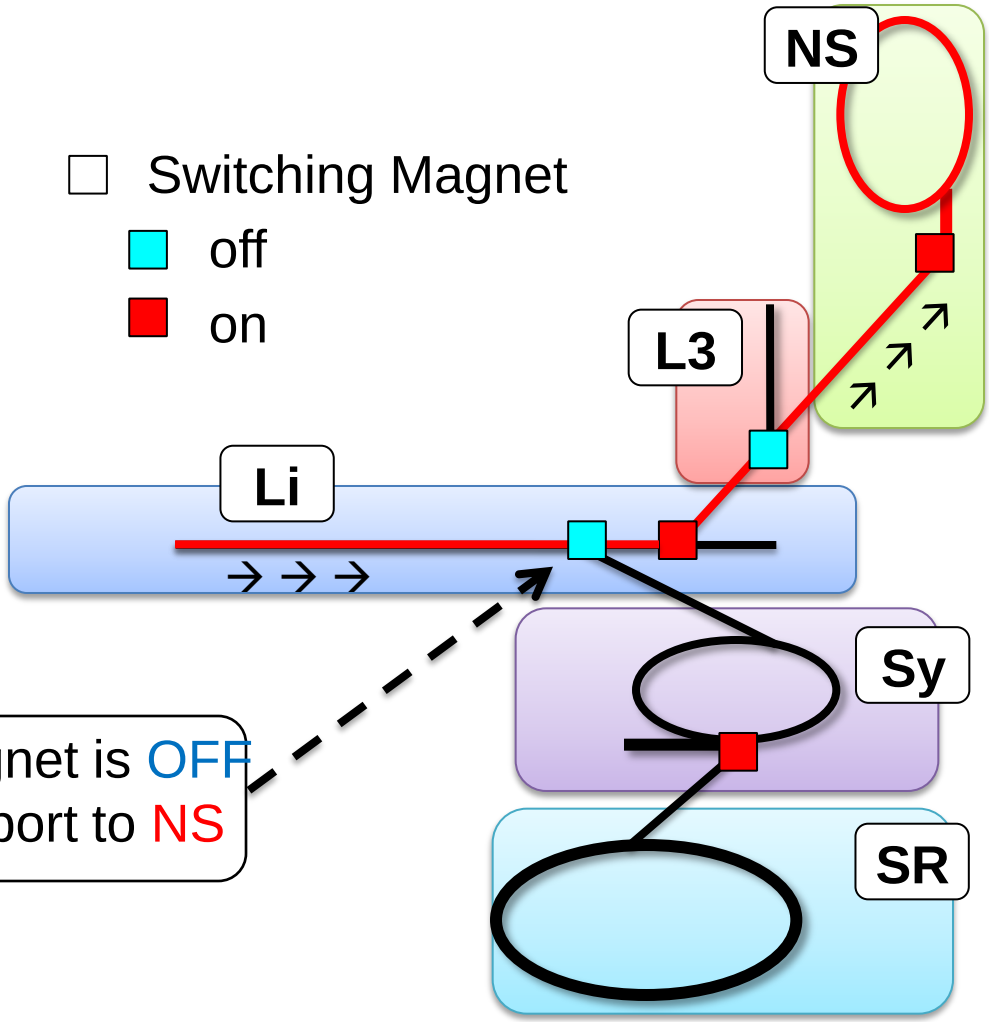
SPring-8 Accelerator complex

Various Accelerator Operations

SR/NS injection switching operation mode

Features of operation:

- Switch a destination frequently
- Top-up operation:
  continuous injection



SPring-8 Accelerator complex

History of Accelerator Operation MODE

The number of Operation mode (MODE):

At the beginning (1997~),
Accelerator complex consist of
Li, Sy and SR

List of operation mode (part.)

- READY Mode
- L2 Mode
- Sy-injection Mode
- SR-injection Mode
- SR-storage Mode
- L2 + Sy-storage Mode
- L2 + Sy-storage + SR-storage Mode

⋮

⋮

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  - L3 beam-transport added

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- NS-storage Mode
- L2 + Sy-storage + NS-storage Mode
- L2 + Sy-storage + SR-storage + NS-storage Mode
- Sy-injection + SR-storage + NS-storage Mode
- NS-injection + Sy-storage + SR-storage Mode
- SR-storage + NS-storage Mode

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- NS-injection + Sy-storage + SR-storage Mode
- SR-storage + NS-storage Mode
- Topup Mode
- Topup + NS-storage Mode

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History of Accelerator Operation MODE

The number of Operation mode (MODE):

At the beginning (1997~),
Accelerator complex consist of
Li, Sy and SR

- The number of MODE had increased as accelerator upgrade
  - L3 beam-transport added
  - NS storage-ring added
  - Topup operation started
  - Destination switching operation started

→The number of MODEs drastically increased (up to around 60 modes)

Many MODEs!

List of operation mode (part.)

- READY Mode
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- Sy-injection + SR-storage + NS-storage Mode
- NS-injection + Sy-storage + SR-storage Mode
- SR-storage + NS-storage Mode
- Topup Mode
- Topup + NS-storage Mode
- Sy・NS-injection Mode
- SR・NS-injection Mode
- Topup・NS-injection Mode

:
:

Old Accelerator Safety Interlock System

Old design concept:
operation MODE based
Safety interlock deeply relates with accelerator operation MODE

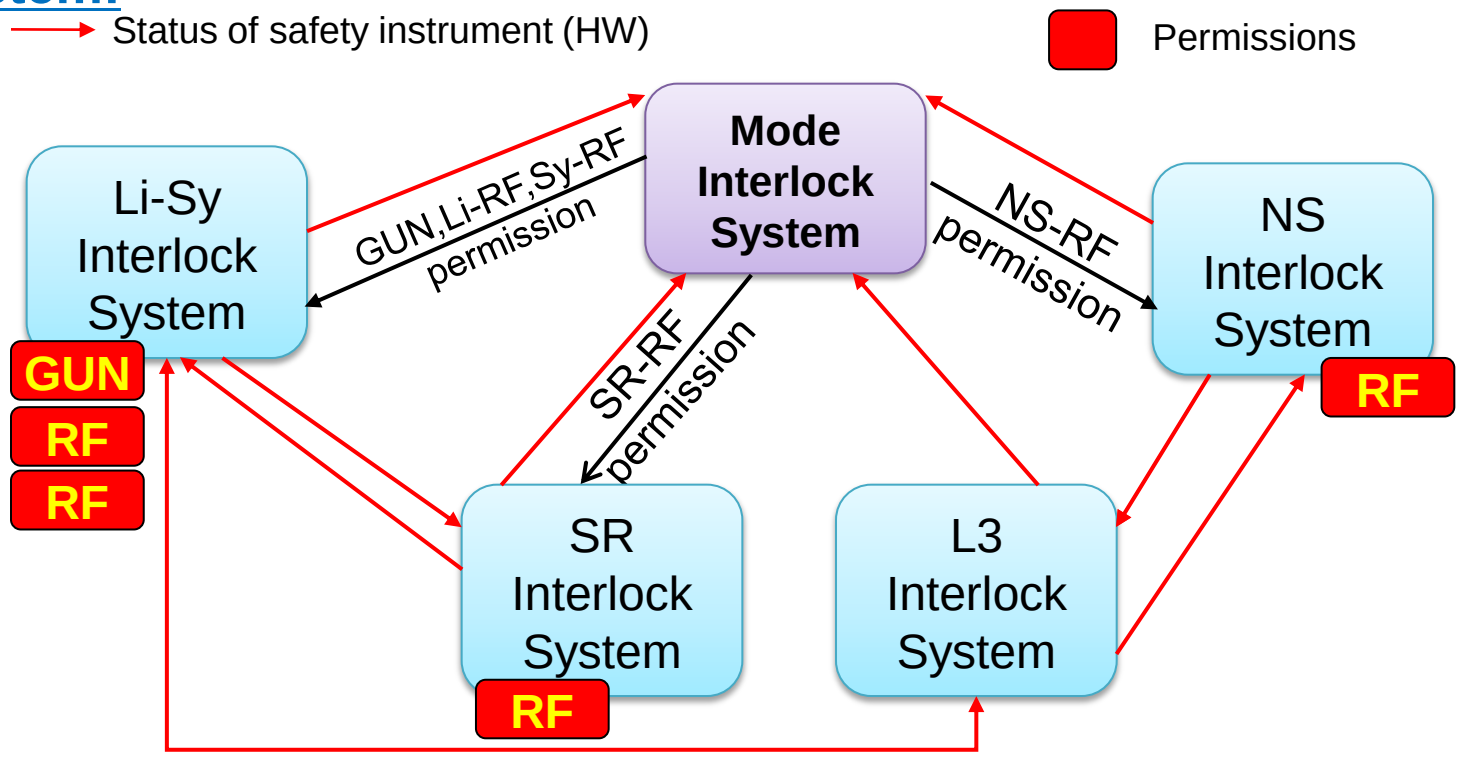
- MODE for interlock system also increased as accelerator operation MODE increase

- For additional accelerator area,
60 → 120 MODEs ?

- Complicated safety logic

Old Accelerator Safety Interlock System

MODE based system:



old Accelerator Safety Interlock System component

MODE system :

- integrate safety instrument status of all areas
- determine permissions (GUN/RF)

problem:

- complicated interlock structure (two-way communication etc.)
- incomplete area separation

Motivation
- New radiation Safety Interlock system -

Old design concept → hard to improve

problems:

- much cost (person, time) for safety inspection
- hard to modify the system due to complicated safety logic and system structure

"New design concept!!"

- Easier maintenance, modification and troubleshoot
- High extendibility for additional new accelerator area

New design concept

New task force formed to establish new design concept:

Experts in each division cooperated,

- Control div. (Accelerator Interlock system)
- Accelerator div. (Accelerator operation)
- Safety office

Many experts discussed various issue (2005 ~)

New design concept

Old design concept:

“ MODE based system”

The number of MODEs exponentially increase by adding an new accelerator area

We had to find efficient concept

New design concept

Old design concept:

“ MODE based system”

The number of MODEs exponentially increase by adding an new accelerator area

We had to find efficient concept

Area management

New design concept

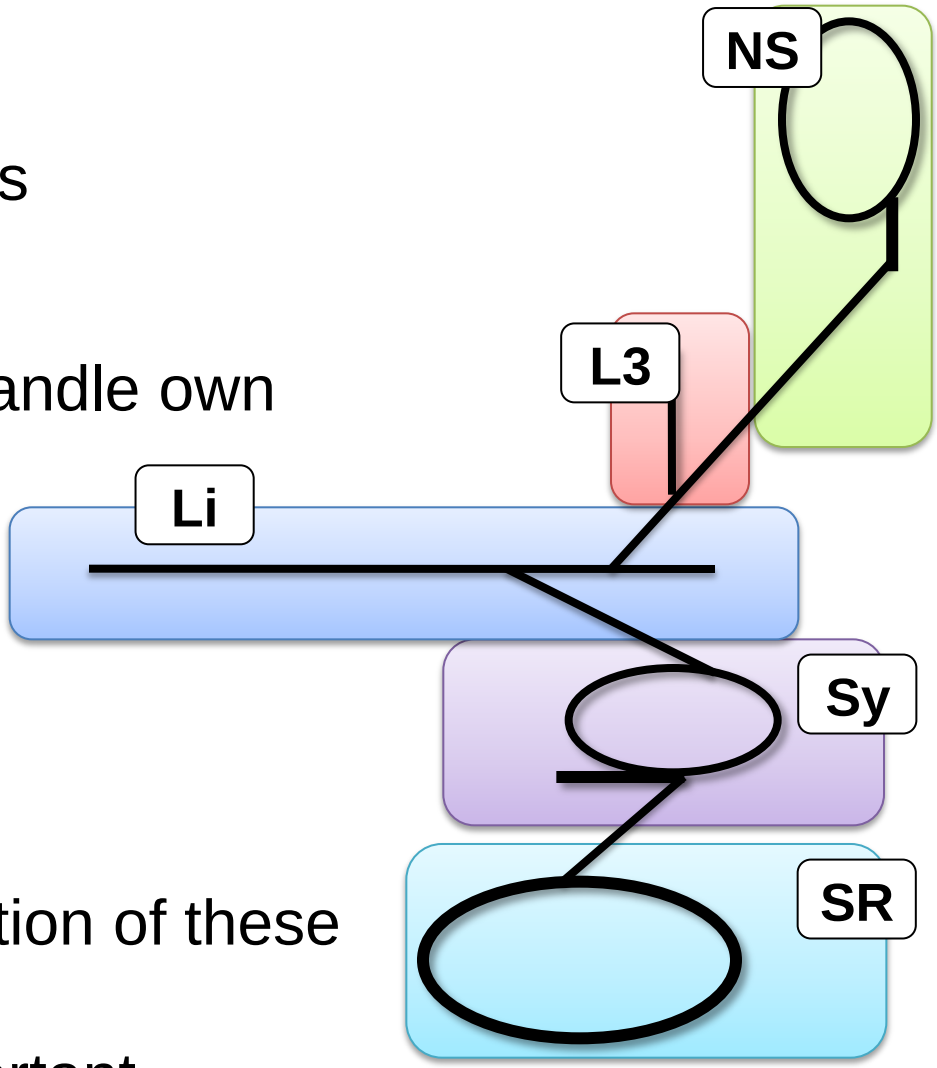
What is area management?

SPring-8:

5 access controlled areas

Each area system should handle own area status independently

1) Access control
2) GUN RF permissions
3) Beam injection



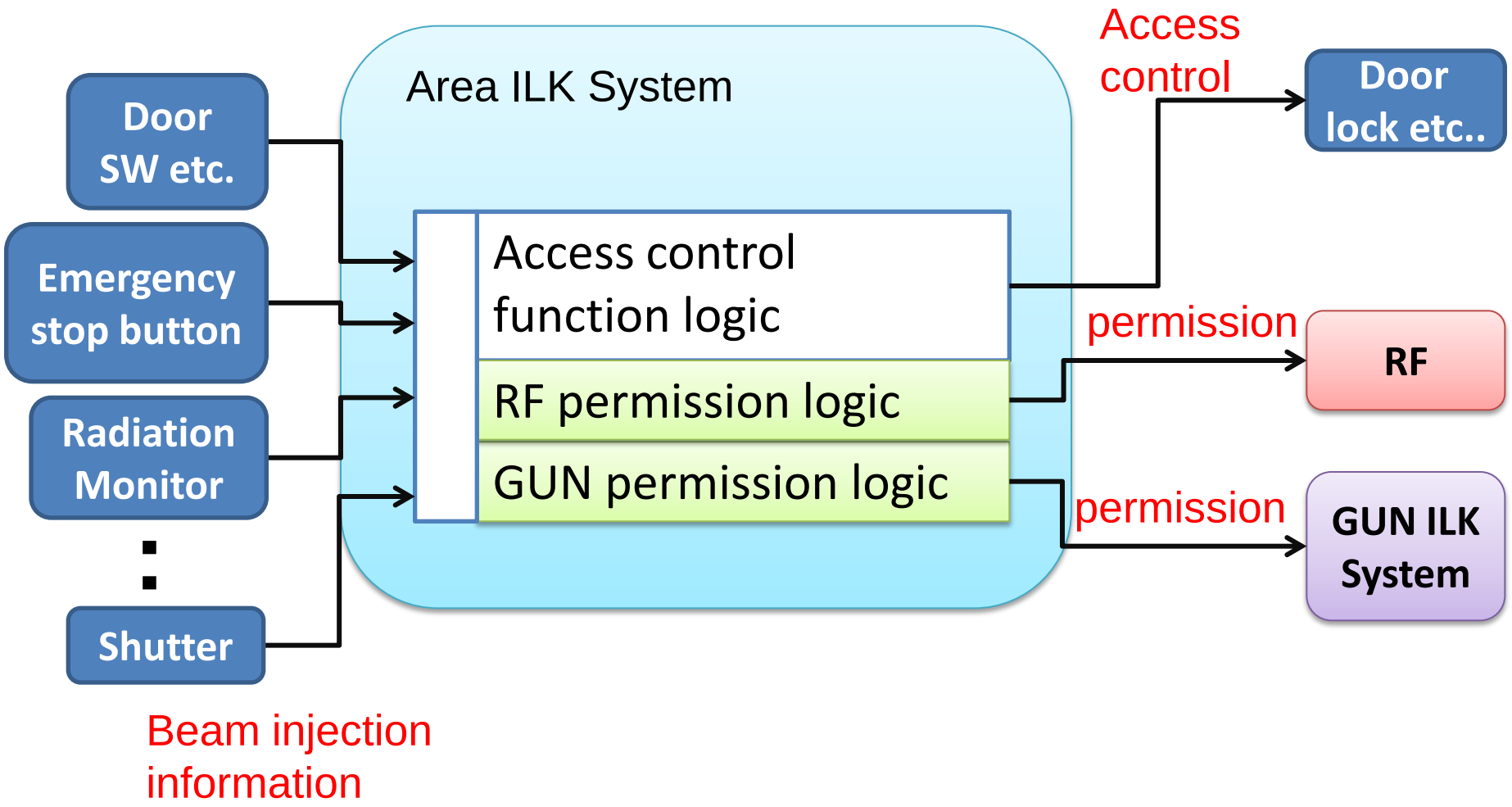
SPring-8 Accelerator complex

MODE: manage the combination of these areas

→ combination is not important

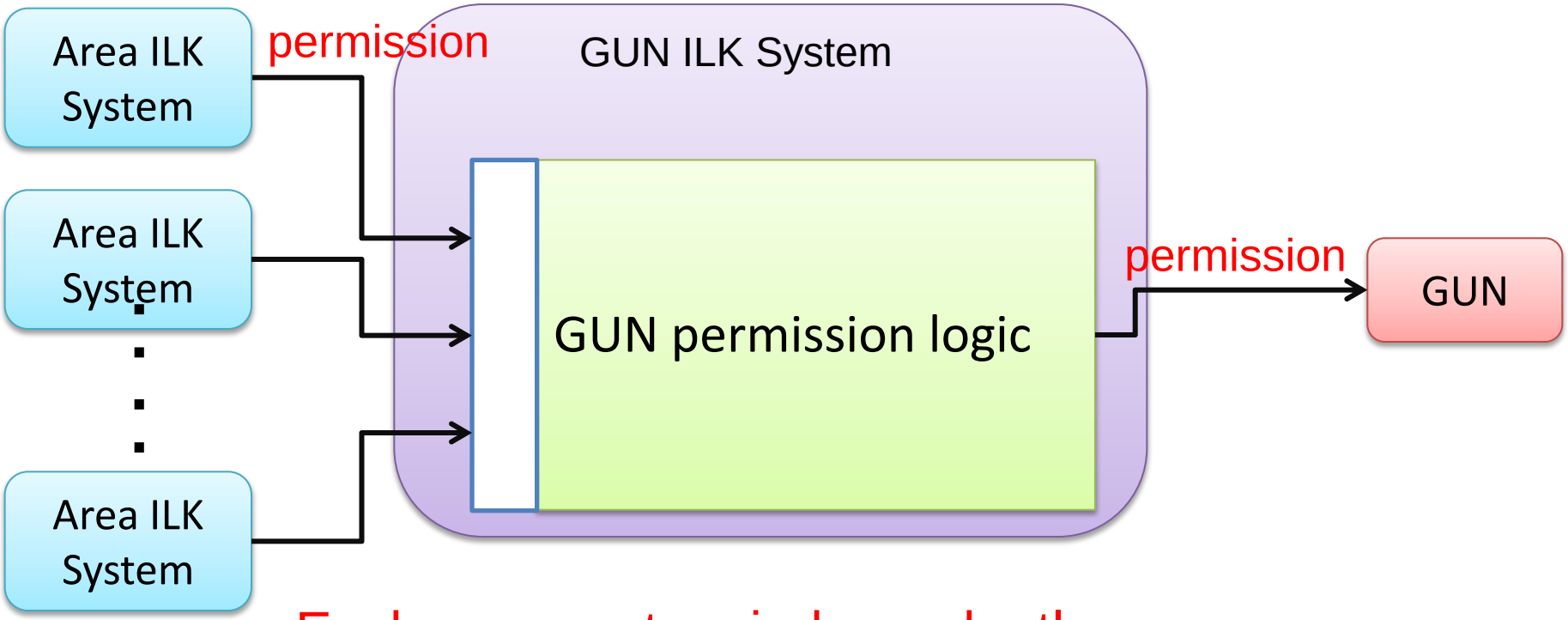
New design concept

Access controlled AREA design concept:



New design concept

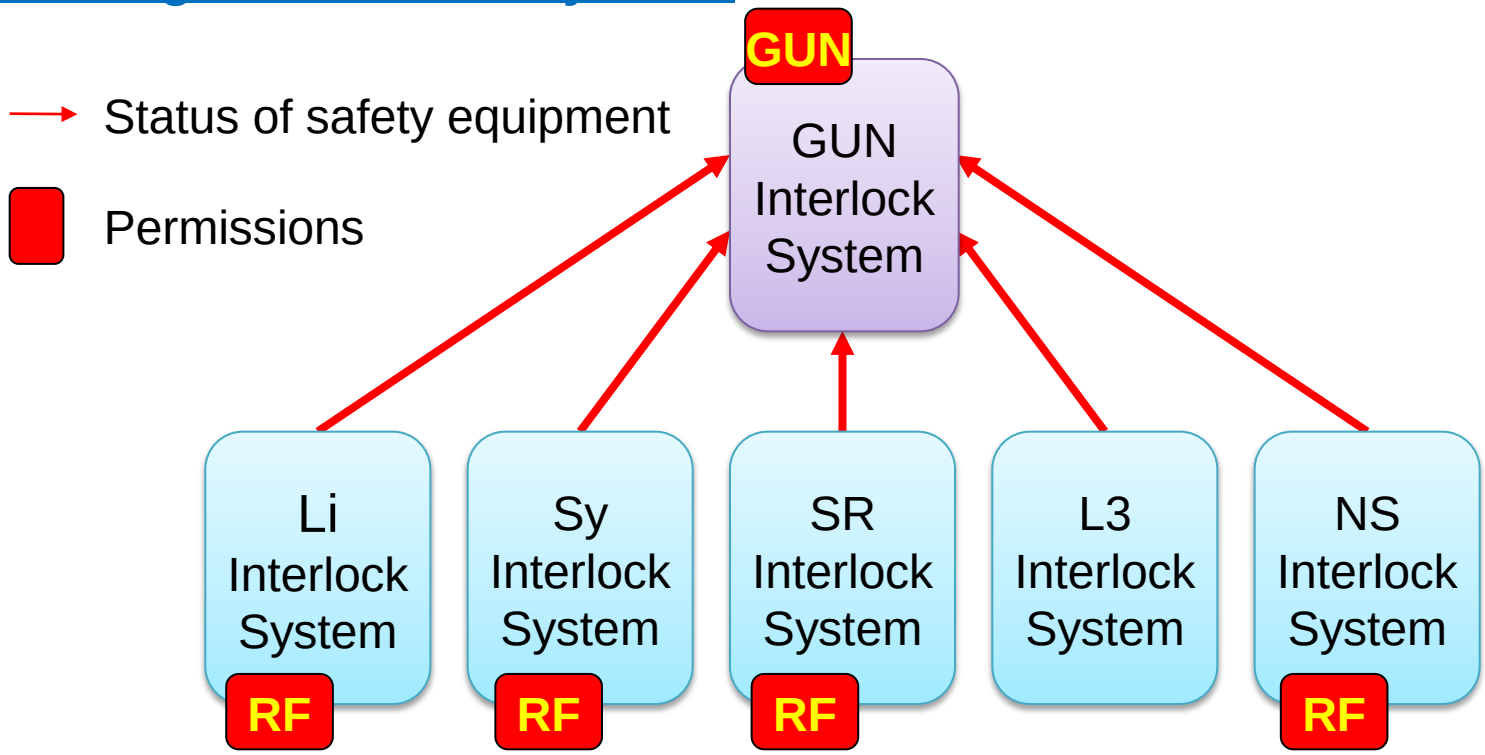
GUN design concept:



- Each area system independently manage
  - Accelerator area
  - Permissions (GUN/RF)
- Acc. area system only communicates with GUN system by one way direction
- No MODE management system

New radiation safety interlock system

Area management based system:



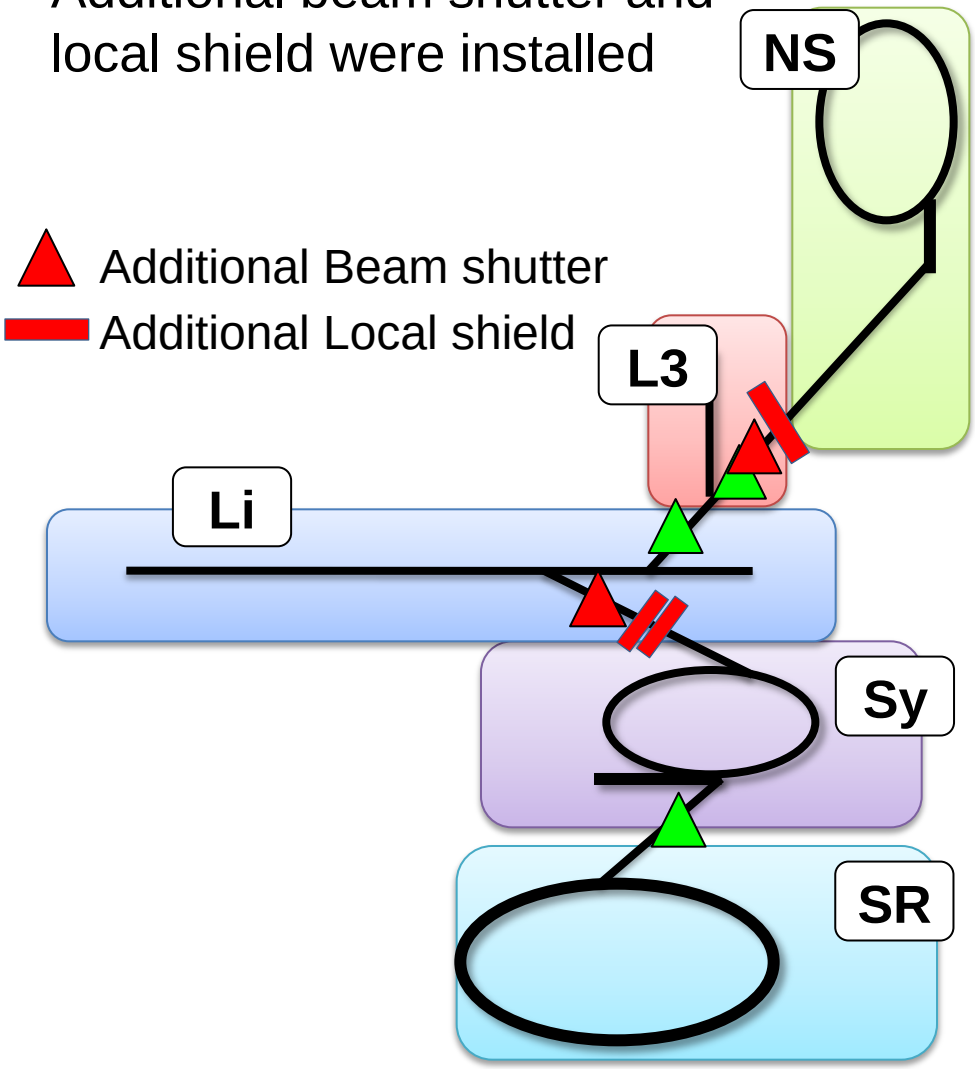
Li area, Sy area, GUN permission → independent system

For area separation:
Shutter should be installed for all AREA to know the beam injection

Accelerator system upgrade

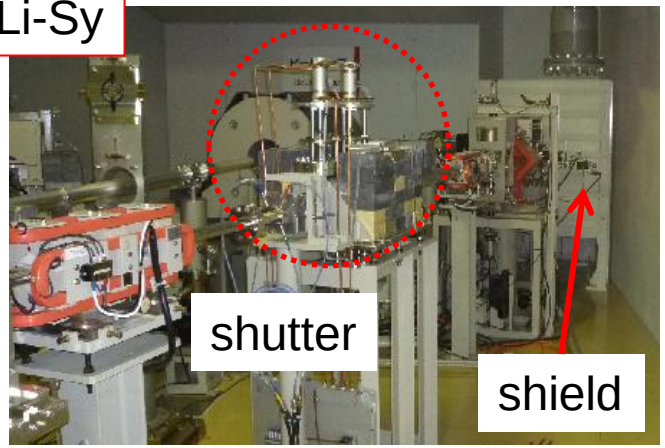
Shutter installation:

Additional beam shutter and local shield were installed

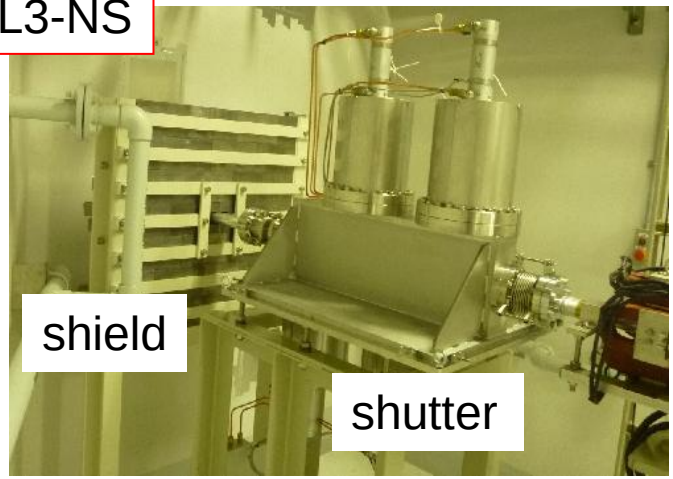


SPring-8 Accelerator complex

Li-Sy



L3-NS



All areas were properly separated

Radiation safety interlock system upgrade

- Many things to do
(SPring-8 has large and many facilities)

Construction

- Replacement of all safety instruments
- New safety logic and software for PLCs (for 6 systems)
- Status monitoring/display system
- Wiring/Re-wiring (Signal/Power/Network)
- Simulator for new safety logic software

For starting accelerator operation

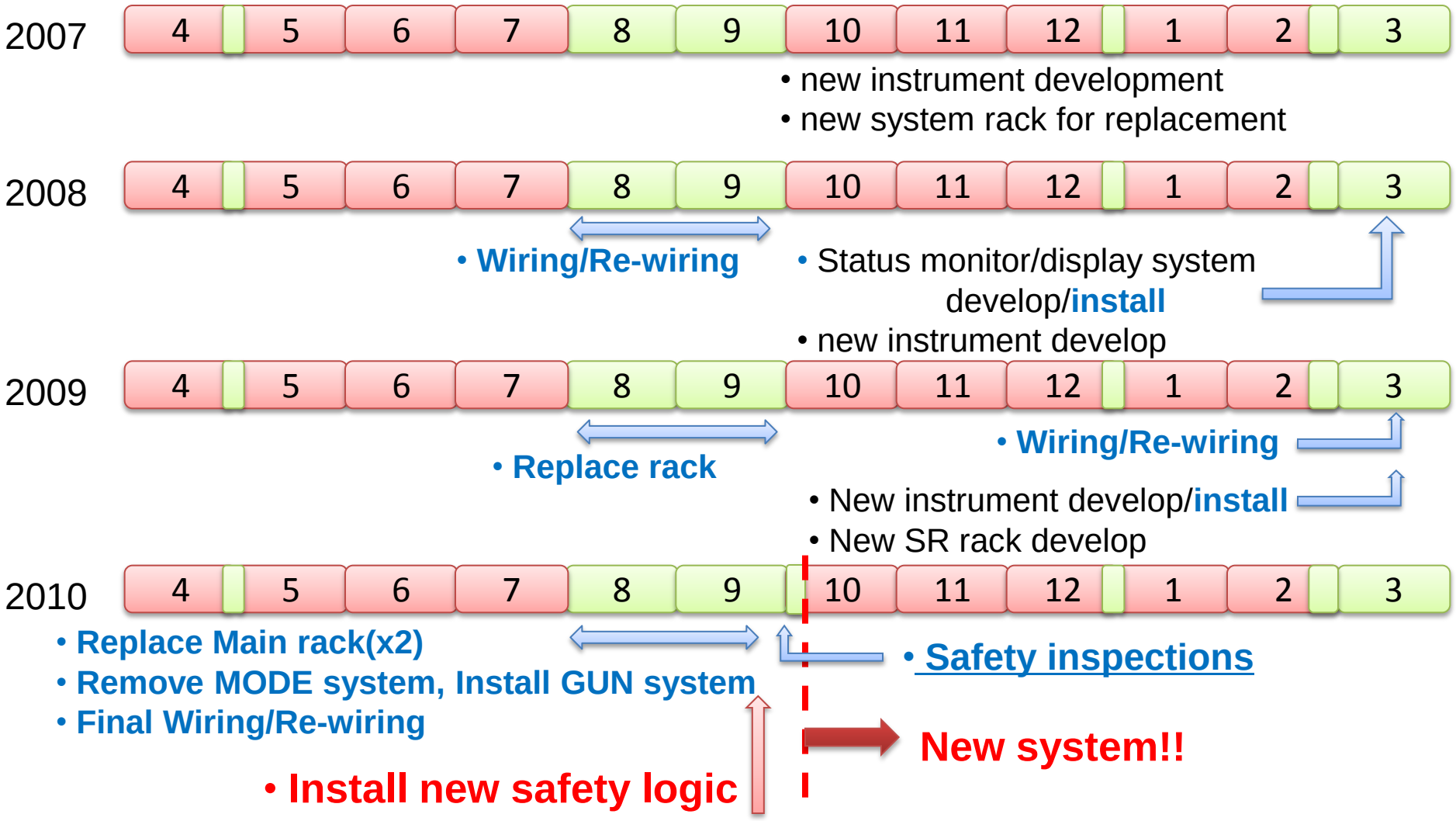
- Internal safety inspection.
- Official safety inspection (with external inspectors)
  → should be passed

-Short shutdown period
- a few chance (twice in a year)

Radiation safety interlock system upgrade

We modified all safety system step-by-step

Construction timeline:



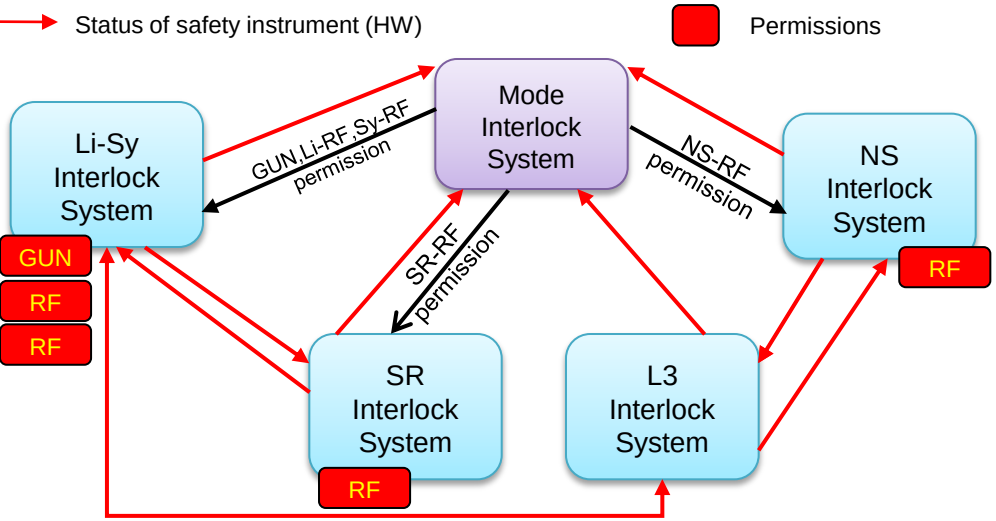
Result

Inspection time:

- Reduced: 5 days → 3 days
- No MODE inspection
  (inspection sheet: ~ reduced to be 40%)

Classified all signals systematically:

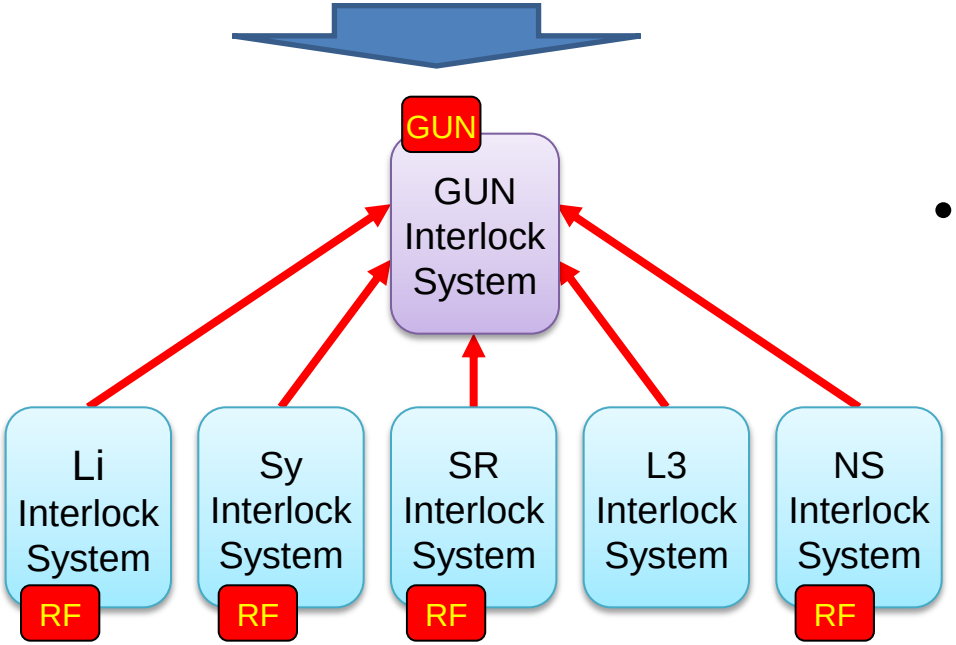
Result



Signals between each systems:

of signals

	Old	New
Area - MODE/GUN	DIO: 48	DI: 11
Area – Area	DIO: 33	0



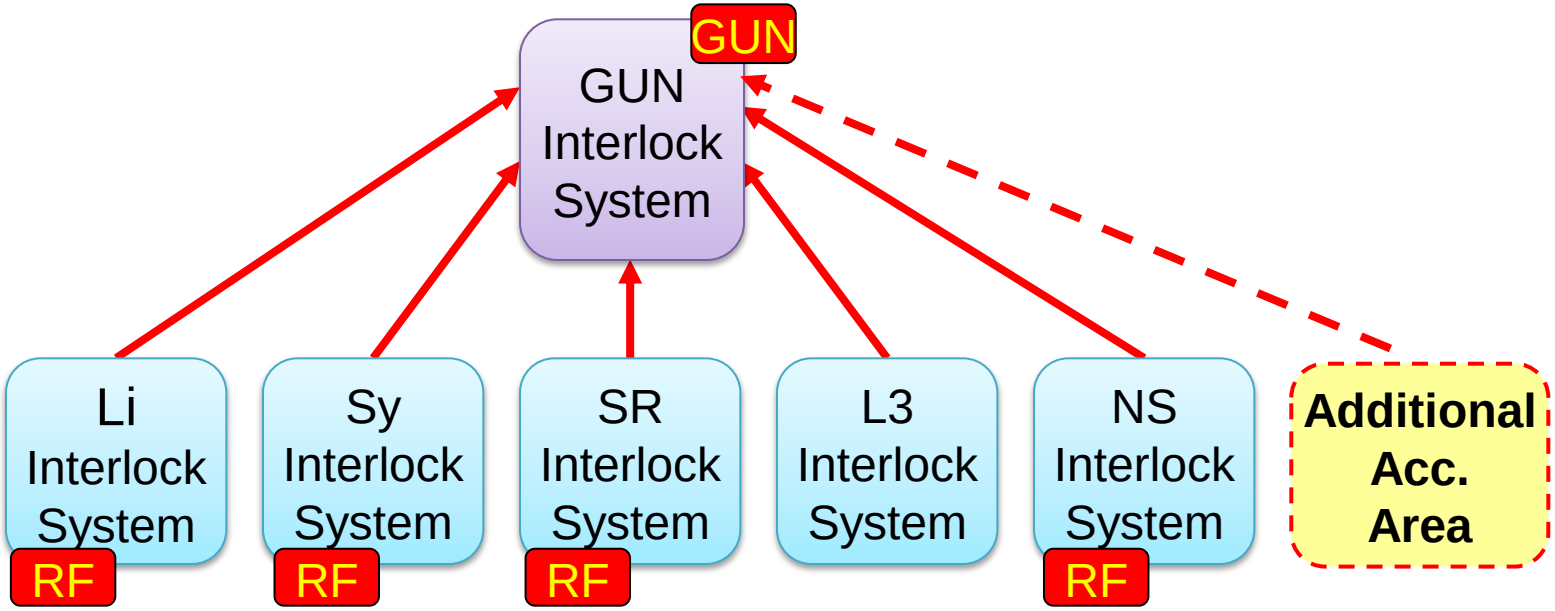
- The number of signal is reduced:
  81 → 11 signals

- Only one way communication from Area to GUN

- Simple/Independent system
- Easier modification and troubleshoot

Result

Additional accelerator area:

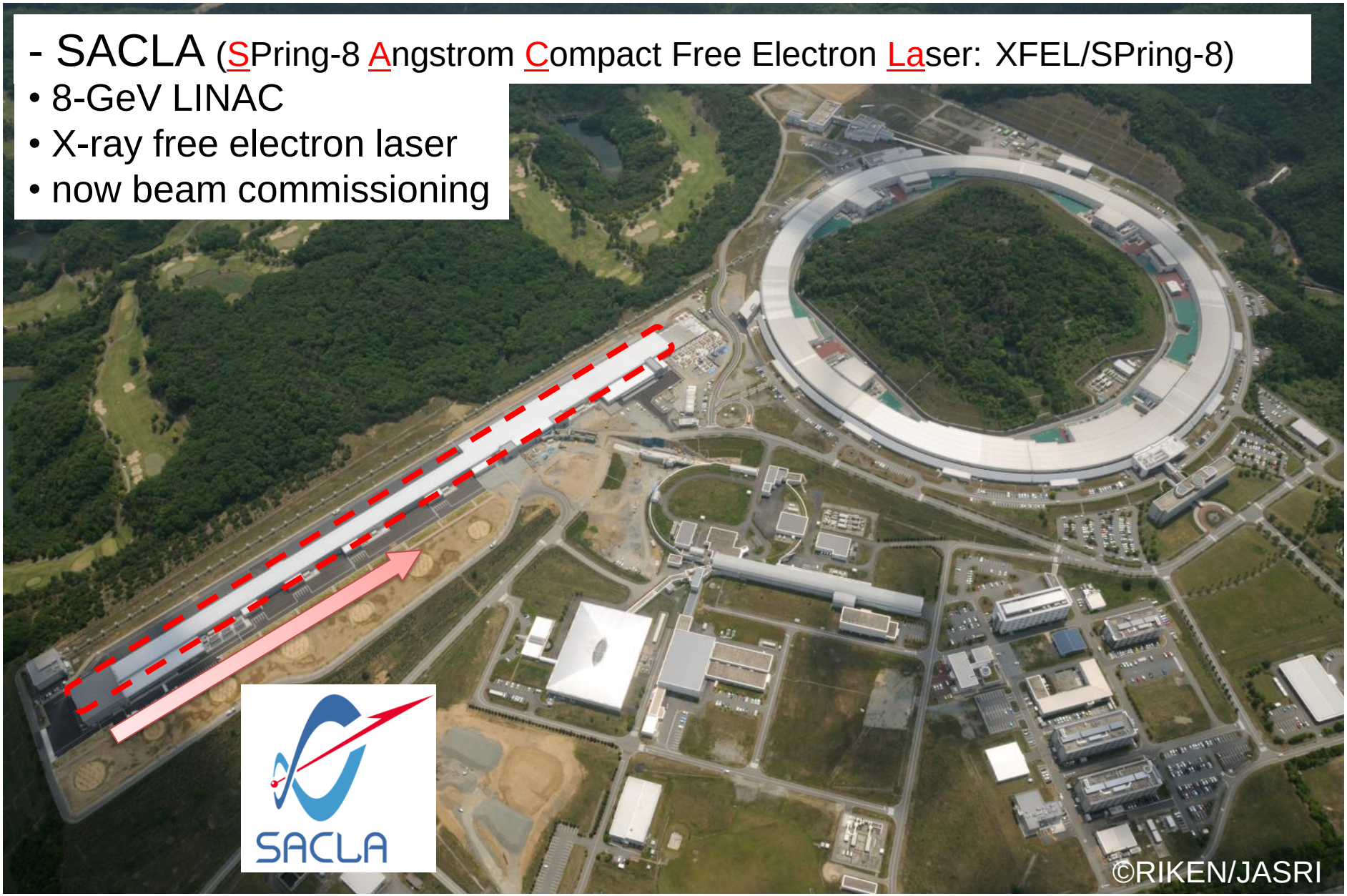


- Access control and permissions → independent

- Communication with other system:
  → only consider GUN interlock system communication

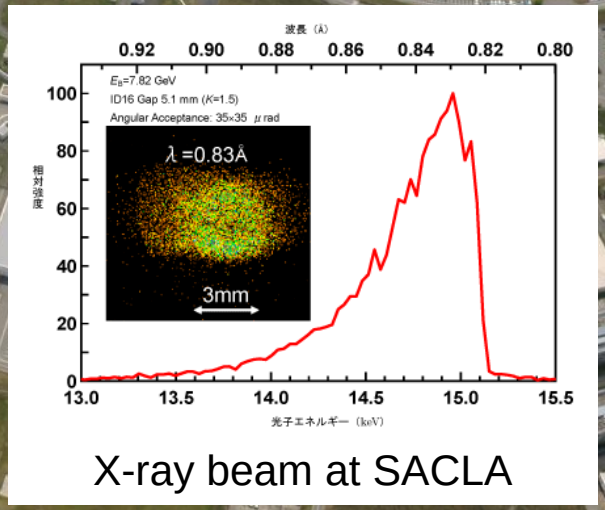
easy to expand for additional accelerator area

New Accelerator, SACLA (XFEL/SPring-8)



New Accelerator, SACLA (XFEL/SPring-8)

- SACLA (SPring-8 Angstrom Compact Free Electron Laser: XFEL/SPring-8)
- 8-GeV LINAC
- X-ray free electron laser
- now beam commissioning



X-ray beam at SACLA

SACLA

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New Accelerator, SACLA (XFEL/SPring-8)

- SACLA (SPring-8 Angstrom Compact Free Electron Laser: XFEL/SPring-8) will be an injector for SPring-8 in the future

Future Plan: SACLA - SPring-8 combined operation

Summary

- We constructed new radiation safety interlock system using “AREA management”

- Simple
  Safety inspection period was reduced
- Reliable
  Easier maintenance, modification and troubleshoot
  Extendibility

- No trouble until now!

Future

SACLA – SPring-8 combined operation